to a great number of flowers, and has come to the conclusion that, however great the analogy between the petals and the leaves, still the former have a series of well-established anatomical features which enable us to characterise them as well as any other part of the plant. Some of their anatomical features can be explained by the physiological function of the organ, whilst the others have no connection with them, and the explanation of these peculiarities must be sought for elsewhere—says the author—in the yet unknown internal structural form of the plant as also, perhaps, in the position occupied by the flower in the whole of its organic life.

In chemistry and physics we notice two papers, by M. Tanatar, on the fumaric and maleinic acids (vol. vi.), and on their compounds with chlorite (vol. viii.); by M. Klimenko, on the lactic and propionic acids (vol. vi.); by M. Melikov, on the compounds of acrilic acid; and by M. Geritch, on electrical phenomena observed during the diffusion of several liquids.

A paper of general interest, intended to show some relations between animals and plants at their lowest degrees of development, is contributed by M. Shmankevitch (vol. vii.). When the Flagellate, *Anisonema acinus*, Blütochli—having a relatively high organisation—is cultivated for many generations in a medium which is slowly modified, for instance, in sweet water to which a certain amount of lake salt is added, its structure is modified, in proportion as the concentration of the solution of salt is increased. The individuals become less developed, their size diminishes, and the feeding-canal loses its former development. Numberless intermediate forms between the *Anisonema acinus* and its new, less developed representatives, make their appearance, as well as between these and the still lower *Anisonema sulcatum*, which would be thus but a lower organised variety of the former. When the concentration of the medium in which the *Anisonema* lives is carried on side by side with a change of temperature of the medium, the transformation goes further on, and the lowest *Anisonemæ* are transformed on the one side into algæ-like organisms, and in another direction into organisms which seem to belong to the category of fungi. The individuals not only become smaller, but they give rise also to a progeny long before reaching their full size. Under the influence of the sun's rays the uncoloured Flagellatæ acquire a new physiological function, and develop chlorophyll. "We see thus," the author says, "the beginnings of two kingdoms, animal and vegetable, radiating from one common stem. We see the transformation of one of them into the other, not only in its morphological features, but also in its physiological functions, under the direct influence of physical and chemical agencies. The saline solutions, as compared with sweet water, diminish the size of the lower organisms, and at the same time they contribute towards the development of chlorophyll in the sweet-water algæ, thus giving them, so to say, a more vegetable character, together with an increased productivenes." And further: "While descending from the *Anisonema sulcatum* to a unicellular alga, we see the regressive development, a simplification of organisation; we descend towards the plants containing chlorophyll. . . . While descending from the same *Anisonema* on another branch, we enter into the region of such lower organisms which, under the influence of another medium, do not develop chlorophyll, and having no nutrition from the air, find their food from the substratum; they could be described as parasitic Rhizopodæ, and this the more as from the fungoid form we can ascend, under some circumstances, not only towards the Amœba-like uncoloured Flagellata, but also towards the moving Monad. On the contrary, by reversing the physical agencies, we can arrive, from the unicellular alga, as well as from the fungoid form, to an uncoloured form having the structure of the *Anisonema*." The researches of A. Giard, Cienkowsky, and Famintzyn, and some observations by Ray Lankester, seem to be, in the author's opinion, in accordance with the above.

PROFESSOR HAECKEL ON THE ORDERS OF THE RADIOLARIA[1]

[THE following translation of a recent paper of mine, by Miss Nellie Maclagan, has been revised by myself.—ERNST HAECKEL.]

THE "Outline of a Radiolarian System founded on Studies of the *Challenger* Radiolaria," published by me in the *Jenaische Zeitschrift für Naturwissenschaft* (Bd. xv. pp. 418-472), shortly before starting for Ceylon in October, 1881, gave a very short survey of the systematic results of the researches which I had been carrying on since 1876 among the inconceivably rich Radiolarian material of the *Challenger* collection. At that time I distinguished in this Rhizopod class seven different orders (p. 421) and 24 families, containing in all 630 genera ("Prodromus Systematis Radiolarium," *l.c.*, pp. 423-472). I was able even then to distinguish no less than 2000 new species, and this goodly number has since been considerably increased. Further investigations corroborated all the principal essential points of the views then briefly given as to the morphologico-phylogenetic conditions of relation among this Protista class, but I gradually came to simplify my views as to the relation of the principal groups, and have now reduced the seven orders to four, which makes the complicated system much more comprehensible.

The systematic arrangement of the 15 families, given in my "Monographie der Radiolarien," 1862 (following Johann Müller, who first broke ground in his treatise, 1858) was essentially improved by Richard Hertwig, whose admirable work on the "Organismus der Radiolarien," 1879, thoroughly explained for the first time the difficult histology of these Protista, and definitely determined their unicellular nature, despite all peculiar modifications of the cell structure. On the ground of important differences discovered by him in the structure of the membrane of the central capsule, and the consequent varying comportment of the passage of pseudopodia, Hertwig distinguished the following six orders (*l.c.* p. 133):—1. *Thalassicollea*, monozoic uninuclear Radiolarians, having the capsule membrane pierced on all sides: skeleton siliceous, irregular, or wanting. 2 *Sphærozoea*, polyzoic multinuclear Radiolarians, having the capsule membrane pierced on all sides: skeleton siliceous, irregular, or wanting. 3. *Peripylea*, monozoic uninuclear Radiolarians, having the capsule membrane pierced on all sides: skeleton siliceous, consisting of fenestrated spheres or modified fenestrated spheres or disks. 4. *Acanthometrea*, monozoic uninuclear Radiolarians, having the capsule membrane pierced on all sides: skeleton non-siliceous, consisting of twenty spicules arranged according to J. Müller's law. 5. *Monopylea*, monozoic uninuclear Radiolarians, the capsule open on one side, and with a peculiar porous area: skeleton siliceous. 6. *Tripylea*, monozoic uninuclear Radiolarians; capsule membrane double, with one principal and two accessory openings; skeleton siliceous, formed of tubes.

As I found that the important differences in the structure of the membrane of the central capsule and the consequent passage of the pseudopodia, discovered by Hertwig in the comparatively limited material at his disposal, were corroborated in their most essential points by my researches among the wider world of the *Challenger* Radiolaria, I adopted his scheme in my "Conspectus Ordinum Radiolarium Classis," 1881 (*l.c.* p. 421), but with this difference, that I divided Hertwig's *Sphærozoea* into two orders—*Symbelaria* and *Syncollaria*. The latter, *Syncollaria*, includes the families of the *Sphæroïdoida* in the wider sense, and, from the absence or incompleteness of the skeleton, corresponds as a polyzoic group to the monozoic *Thalassicollea*, whilst the former, *Symbelaria*, includes the family of the *Collosphærida* in the wider sense, and by its spherical, reticulate, siliceous skeleton corresponds as a polyzoic group to the monozoic *Peripylea*.

Recent researches, which have brought to light an immense number of new, hitherto unknown Radiolarians belonging to the last-mentioned groups, have, however, convinced me that the distinction between the monozoic (solitary) and the polyzoic (social) Radiolarians is of much less importance than was formerly supposed. They are as insignificant and of as little value in forming a system as the differences between monozoic Hydropolyps (*e.g. Hydra*, *Myriothela*) and polyzoic Hydropolyps (*Tubularia*, *Coryne*), or as the differences between solitary Infusoria (*Vorticella*, *Trichodina*) and social Infusoria (*Carchesium*, *Epistylis*). According to Hertwig, the essential difference between the two groups is that the solitary *Thalassicollea* are uninuclear, the social *Sphærozoea* (= *Symbelaria*) multinuclear. Nevertheless, the central capsule in all Radiolaria (without exception) is uninuclear at an early stage and multinuclear later on. We would require to be more exact about this distinction, inasmuch as in the *Sphærozoea* (= as in the *Acanthometrea*) the division of the simple nucleus into a number of nuclei (spore nuclei) takes place at a very early period, whilst in the *Thalassicollea* (as in the other Radiolaria) it only takes place later on. This relative modification is, however, of no standard value

[1] "Separat-Abdrück aus den Sitzungsberichten der Jenaischen Gesellschaft für Medicin. und Wissenschaft." Jahrg. 1883. Sitzung. von 16 Februar.

for the systematic distinction of the orders, and is, moreover, subject to various exceptions.

Among the new Radiolaria of the groups above mentioned discovered in the *Challenger* collection, there were, moreover, monozoic and polyzoic species which correspond completely, even in the specific characteristics of the skeletal form. For example, a monozoic *Thalassoxanthium* has precisely the same characteristic spicules as the common cosmopolitan *Sphærozoum punctatum*, but whilst in the latter the small polyzoic central capsule incloses a large central oil globule and numerous small peripheric nuclei, in the former the central capsule, which is three times as large, incloses a single, large central nucleus and numerous small peripheric oil globules. The complete identity of the characteristic skeletal form might even lead us to suppose that a kind of alternation of generation may take place between the two forms. In the same way, a social *Collosphæra* corresponds completely to a solitary *Cenosphæra*, the polyzoic *Acrosphæra* to the monozoic *Conosphæra*, and so forth.

On the ground of these observations—the importance of which I shall explain in detail in my work on the *Challenger* Radiolaria—I consider the distinction between monozoic and polyzoic Radiolarians (which I contrasted in 1862, according to Müller, as *Monocyttaria* and *Polycyttaria*) as practically unimportant, and for the present connect the polyzoic families in the system immediately with the monozoic. In this way the number of the six or seven groups is reduced to four, as I refer all the groups thus formed to Hertwig's Peripylea. As I have already shown (1881, *l.c.* p. 421), these may be again divided in pairs into two principal groups or sub-classes—into *Holotrypasta* and *Merotrypasta*. The *Holotrypasta* (*Acantharia* and *Peripylea*, the latter including the *Collodaria*, *Symbelaria*, and *Syncollaria*) includes all Radiolaria in which the capsule membrane is pierced on all sides by fine pores, and the pseudopodia consequently radiate equally on all sides. The *Merotrypasta* (*Monopylaria* and *Phæodaria*) include all those Radiolaria in which the membrane is pierced at one side either by a single area of pores or by openings confined to a few spots, so that the pseudopodia project from the central capsule as a single bunch or as slightly separated bunches.

The high standard importance of the central capsule for the proper conception of the Radiolaria to which I first drew attention in my monograph, 1862, has since been recognised by Hertwig and most other investigators of these Protista, but recently disputed by Carl Brandt (*Monatsb. Berlin. Akad.* 1881, p. 391). As I reserve the detailed reasons for my opinion for my work on the *Challenger* Radiolaria, I shall now merely remark that my more recent researches have fully corroborated my former views, and that in all true Radiolaria the central capsule is separated by a distinct membrane from the extracapsularium (or external gelatinous soft part). The so-called "freshwater" Radiolaria (which, from absence of the membrane, are not Radiolaria but Helizoa) do not of course furnish any counter-proof. Brandt's erroneous assertion rests upon the extremely limited amount of material investigated by him. Careful investigation enabled me to discover the capsule, even in all species which he regards as "without capsule." In isolated species, however, the capsule membrane is somewhat late in forming a definite boundary between the capsule and the gelatinous sheath (sometimes just before the formation of spores), whilst in other cases it usually takes places at a very early stage. I therefore maintain now, as formerly, that the chief character of the class is the differentiation of the unicellular body into two essential, principal component parts, viz. the inner central capsule with nucleus and membrane, and the outer gelatinous sheath with matrix and forest of pseudopodia. On the other hand, it is immaterial whether "yellow cells" (or "zooxanthella") are present or not. I found them wanting in many cases, though they are usually present. I therefore agree with Cienkorosky, and regard the symbiosis of these unicellular Algæ as an accidental and not an essential phenomenon. They are in no way necessary for the nourishment of the Radiolaria, though they may be important agents in the matter.

Meantime I am convinced that the four orders of the class Radiolaria, *Acantharia*, *Spumellaria*, *Nassellaria*, and *Phæodaria* represent four distinct, perfectly natural, principal divisions. In each of these four orders the numerous forms belonging to it, despite their astonishing variety, may be referred by morphological comparison to a common primitive form, which may therefore be regarded as their ancestral form in a phylogenetic sense. This phylogenetic view of the four orders as distinct monophyletic groups is justified by the fact that the remarkable and extremely complicated relations of all the forms of each common ancestral group have the same natural, strong phylogenetic signification as they have in the comparative anatomy of the Vertebrata or of the Articulata. Bütschli was therefore in the right at the close of his admirable dissertation on the skeletons of the Cyrtida (1881, *l.c.* p. 538), where he lays stress on the fact that the complicated phylogenesis of this section, so rich in specific forms, may be regarded as an excellent argument in favour of the doctrine of descent, and that in this way those painstaking investigations of the microscopic world (which many "exact physiologists" consider mere morphological trifling) come to be of real importance.

I. The Acantharia, which are distinguished from the three other orders by their organic acanthine skeleton—they never have a true siliceous skeleton—correspond on the whole to the *Acanthometræ* of J. Müller (including, however, part of the *Haliomma*), and to the *Acanthometreæ* of Hertwig, which he divides into *Acanthometrida* and *Acanthophractida*. I hold the remarkable *Actinelius* to be the ancestral form of this order. It was first described by me in 1865, but I have lately found several forms closely allied to it, partly Astrolophida, partly Litholophida, in the *Challenger* collection. In *Actinelius* the spherical central capsule is pierced by numerous simple, radial spicules (without definite number and arrangement) meeting in the centre of the capsule. *Actinelius* may be held to have arisen immediately from *Actinosphærium* by the hardening of the firmer axial fibres in the radial pseudopodia of the latter into radial spicules. *Actinelius* is the common ancestral form, on the one hand, of the whole *Actinelidæ* (Astrolophida and Litholophida), all with indefinite number and arrangement of the spicules, and, on the other hand, of the remaining *Acantharia*, in which twenty radial spicules are invariably arranged according to J. Müller's law in five four-rayed zones. The oldest of these are the Acanthonida (or Acanthometra in the more limited sense) from which the Dorataspida and Diploconida having shells are derived later on.

II. The Spumellaria, by which I understand Hertwig's *Peripylea*, *Thalassicollea*, and *Sphærozoea*, had been previously united with tolerable accuracy by Ehrenberg, on the ground of observations made by him on the skeletons of the fossil Radiolaria of the Barbadoes, and opposed to the Nassellaria as *Polydictya* or *Polycystina composita*. His *Spyridina* (our *Spyroida*) belongs, however, to the latter, not to the former. All Spumellaria (which may also ultimately be termed Peripylaria or *Peripylea*) have—in contradistinction to the Nassellaria and Phæodaria—a central capsule pierced on all sides by fine pores, and agree in this respect with the Acantharia, from which, however, they are distinguished by the absence of the acanthine skeleton. All Spumellaria may be easily referred to a common ancestral form—to *Actissa*, the simplest form of the Thalassicollida. An interesting species belonging to *Actissa* was accurately described by Hertwig in 1870, under the name *Thalassolampe primordialis* ("Organismus," p. 32, taf. iii. fig. 5). It has neither the extracapsular alveola of *Thalassolampe* nor the intracapsular alveola of *Thalassicolla*. I observed another species of the genus, which I shall describe later in detail, as *Actissa princeps* in Ceylon, 1881. *Actissa* certainly represents the simplest possible Radiolarian form, in a measure the actual embodiment of the simplest ideal type of this whole Rhizopod class. In a phylogenetic sense it may therefore claim to be regarded as the ancestral form not only of all Spumellaria, but perhaps also of all Radiolaria. All *Collodaria* (the solitary Thalassicollida and Thalassosphærida, the social Collozoida and Sphærozoida) are derived immediately from it, then all *Sphærellaria*. The ancestral group of the latter section, which is richest of all in specific forms, is the *Sphæroida* (or *Sphærida*), and, first among them, the Monosphærida, furnished with a simple, fenestrated spherical shell. From the latter all the others, viz. Pylonida, Zygastida, Discoida, and Lithelida, can be derived without difficulty.

III. The Nassellaria, which correspond on the whole to Hertwig's Monopylea, had already been defined by Ehrenberg as *Monodycta* or *Polycystina solitaria*, in contrast to his Spumellaria. His definition was correct on the whole, though the *Spyridina* (our *Spyroida*), which he places among the latter, belong rather to the former. Hertwig was the first to determine correctly the essential characters of this large order, so wonderfully rich in forms, viz. the simple area of pores at one pole of the capsule axis, 1879 (*l.c.*), and I would therefore have retained his name, *Monopylea* or *Monopylaria*, for the entire order, had it not been equally suitable to part of the Phæodaria. I therefore prefer

Ehrenberg's older nomenclature. Like Hertwig, I regard the skeletonless *Cystidium inerme*, discovered by him (*l.c.* pp. 87, 136, taf. vii. fig. 1) as the ancestral form of the order. *Cystidium inerme* is distinguished essentially from *Actissa* by the restriction of the capsule pores to a single area, and the consequent monaxonous fundamental form of the central capsule. All other Nassellaria are derived from *Cystidium* by the development of a characteristic siliceous skeleton. Hertwig assumes that there are at least two or three entirely different original forms for the Nassellaria skeleton, viz. a simple siliceous ring (*Lithocircus*) for the Cricoid skeleton of the Acanthodesmida and Zygocystida, and a triradial siliceous framework consisting of three spicules united at one point (*Plagiacantha*) for the Plagiacanthida and Cystida (*l.c.* p. 126, &c.). I then endeavoured to refer these two fundamental forms to a single form, as I made out the combination of the simple siliceous ring and the triradial framework in many Cystida and Spyroida (or Zygocystida). In my "Prodromus" (October, 1881, *l.c.* pp. 423-444) I divided the Nassellaria order into five families, and placed the *Plectida* (with triradial siliceous framework) as the common ancestral group. From it I derived first all the *Cystida*, from these again the *Botryoida* and *Spyrida* (=Zygocystida), and from the latter the *Stephida* (= Cricoidea). At the same time, and quite independently of my researches, Bütschli was busy with the same morphological problem, and arrived at essentially the same conclusion, except that he reversed the phylogenetic series of the forms. In his admirable treatise on the skeletons of the Cystida (also dated October, 1881, published in the *Zeit. f. wissen. Zoologie*, 1882, bd. 36, p. 485) he tries to prove the morphological connection of all Nassellaria (his *Cricoidea*), but regards the *Stephida* (= *Acanthodesmida*) as the primitive ancestral form, not as the last degenerated scion, an opinion which I myself formerly shared (compare Hertwig, 1879, p. 126). Which of these two opinions is correct cannot be determined at present. Important facts favour my present view, that the triradial siliceous framework may be the common ancestral form of all Nassellaria (*Triplagia*, *Plagiacantha*). Again, other important facts favour Bütschli's view that this ancestral form may be the simple siliceous ring (*Lithocircus*, *Monostephus*). Finally, there are good grounds for supporting Hertwig's opinion, that both these ancestral forms (the triradial and the annular) may have arisen independently from the skeletonless Cystidium. I shall discuss this difficult and interesting question at length in my work on the *Challenger* Radiolaria.

IV. The Phæodaria were only known up to 1876 by three types described by me in 1862 (*Aulocantha*, *Aulosphæra*, *Cælodendrum*). By the discovery of numerous forms in the *Challenger* collection this has since acquired an importance of which we had no previous idea, as those Radiolarians far surpass all others both in size and singularity of form, as well as in peculiar combinations of structure. In my preliminary paper on the Phæodaria, 1879 (*Jena. Naturwissen. Sitzungsb.*, December 12) I distinguished 10 families with 38 genera, a number which has since been increased considerably by the continuous and astonishing discovery of new forms. As in the majority of these the skeleton is composed of hollow, siliceous tubes (differing therefore from that of all other Radiolarians), I termed the whole order *Pansolenia*, 1878 ("Protistenreich," p. 102). This name, however, suits all members of the family as little as the name *Tripylea*, proposed by Hertwig, 1879. On the other hand, the present name *Phæodaria* indicates the common characteristic of the whole order, the peculiar *phæodium*, a voluminous, dark body of pigment, lying excentrically outside the central capsule. The latter is, moreover, universally distinguished by its double membrane and by the peculiar opening furnished with a radiated operculum, which lies at the pole of the axis, and may therefore be termed the principal opening. In addition to it there are usually (though by no means invariably) two small accessory openings, lying one beside the other at the opposite (aboral) pole. Sometimes there are more than two, whilst at other times they are entirely wanting. Despite the extraordinary diversity of the peculiar, and often very complicated siliceous skeleton, all Phæodaria may likewise be derived from a common ancestral form—the skeletonless *Phæodina*.

The further phylogenetic question, whether all the hypothetic primitive forms already mentioned of the four Radiolarian orders can be referred to a single common primitive form, may now in all probability be decided in the affirmative. From *Actissa* the parent form of the Spumellaria, the ancestral form of the three other orders may be derived without difficulty. *Actinilius*, the ancestral form of the Acantharia, may have arisen from *Actissa* by the thickening of part of the radial pseudopodia into acanthine spicules. *Cystidium*, the probable ancestral form of the Nassellaria, may be derived from *Actissa* by the pores of the capsule membrane, originally developed equally and on all sides, becoming restricted to a single distinct porous area. *Phæodina*, the ancestral form of the Phæodaria may have arisen in a similar way from *Actissa* by the porous area becoming replaced by a single, simple opening, or small, additional, accessory openings, still being left, whilst at the same time the capsule membrane became double, and the pigment mass of the phæodium deposited excentrically round it. Whilst, on the one hand, the simplest Spumellaria form, *Actissa*, may be easily accepted as the ancestral form of all Radiolaria, *Actinosphærium* and *Actinophrys* show, on the other hand, how it may be derived from the simplest Rhizopoda.

(*To be continued.*)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

THE Technical Schools in connection with the University College, Nottingham, will be formally opened by Sir Frederick Bramwell on the 24th inst.

MR. J. T. DUNN, M.Sc., Demonstrator in Chemistry at the College of Science, Newcastle, and formerly Demonstrator in Physics, has been appointed Science Master and Director of the Chemical Laboratory in the High School for Boys, Gateshead. In the Gateshead High School, which opened in May 1883, there are already about 175 boys, and it is intended that all the boys shall learn Physics and Chemistry at some period of their school course.

SCIENTIFIC SERIALS

Journal of Franklin Institute, vol. cxvi. No. 696, December, 1883.—The cheapest point of cut off, by W. D. Marks. Partially based on, and in criticism of, a previous paper by Mr. Hill.—Experiments upon non-conducting coverings for steam pipes, by Prof. J. M. Ordway. In this research calorimeters are used, consisting of sheet-brass vessels so shaped that they can be clamped together outside the steam pipe, inclosing a known length of it and of its covering. Of more than fifty substances tried, simple hair-felt with a cheap cover of burlap proved best; seventeen other compositions owed their efficiency to hair. Asbestos hard pressed was a very bad material; it was non-conductive only in the downy state when full of air.—Pressure attainable by the use of the "Drop Press," by Prof. R. H. Thurston. These presses appear to be very efficient for forging hot iron.—The theory of turbines, by Prof. R. H. Thurston. This is the first part of an abstract of a most valuable mathematical discussion of the subject.—A new valve-motion, by Carl Angstrom. This is a so-called "radial" valve-motion, resembling those of Brown, Marshall, and Joy.—A simple and sensitive thermostat, by Dr. N. A. Randolph, designed for incubation and other experiments in the physiological laboratory. The adjustment is obtained by the more or less closing of the orifice for the gas by the expansion of alcohol causing mercury to rise toward the orifice.

Annalen der Physik und Chemie, xx. No. 12 (*a*), December, 1883.—On the condensation of carbonic acid on smooth surfaces of glass, by Prof. R. Bunsen. The condensation of the gas goes on for years, in spite of continual changes of density and pressure. In three years each square centimetre absorbs, at standard pressure and temperature, 5·135 cubic centimetres of the gas, about two-thirds of this amount being absorbed during the first year.—Density proportions of normal salt solutions, by C. Bender.—The law of rotational dispersion, by E. Lommel.—A simple method of investigating the thermo-, actino-, and piezo-electricity of crystals, by Prof. A. Kundt: consists in applying Lichtenberg's powder.—On the measurement of electric forces by means of the electric mill, by D. Kaempfer.—On the question whether the condensation of steam produces electrification, by S. Kalischer.—On the influence of the hardness of steel on its magnetisability, by V. Strouhal and C. Barus; also, on the influence of annealing on the retentivity of the magnet, by the same authors. These are two very elaborate and important